

Business Process Re-engineering of Production Management Applying Agile Principles

Keiichi FUKUDA*1 • Takaaki IMOTO*1

*1 Digital Innovation Technology Center, Technical Development Group

Abstract

In a changing business environment, it is necessary to promote Digital Transformation (DX) by utilizing digital technology. Additionally, for DX business transformations, which are highly uncertain, it is recommended to apply agile principles. On the basis of this recommendation, Kobe Steel has implemented a business transformation in the production management operations of its titanium plant. This has been achieved through the application of simple business support tools and the Plan-Do-Check-Act (PDCA) cycle for continuous improvement. As a result, it has been confirmed that agile principles are valid for the business transformation of legacy production management operations, which still have numerous constraints and accumulated know-how.

Introduction

Digital technology, external factors such as pandemics and SDGs, and corporate globalization all constitute areas of extreme and rapid change. Against this backdrop, many companies across all industries are promoting business transformation using digital technology - that is, digital transformation (hereafter, DX) - as a critical initiative in maintaining and improving competitiveness. According to a 2022 survey conducted by the Japan Management Association, 55.9% of companies have already started taking measures toward DX, an increase over the previous year. However, a rather small proportion of companies reported achieving good or very good results - only 16.9%.¹⁾ Challenges reported in promoting DX include a shortage of DX experts, insufficient management strategies for DX, and challenges with developing DX into specific businesses, with the methodology for promoting DX cited as a main hurdle.

Much of the literature, such as 2023 DX White Paper published by Information-technology Promotion Agency, Japan suggest that a process in line with the Twelve Principles of Agile Software²⁾ is needed to promote DX.³⁾ Business transformation through DX often entails a high degree of uncertainty surrounding the ultimate goal and whether the technologies can be used as intended. Therefore, rather than devising a detailed plan and simply executing it as written, companies

must begin the transformation based on assumptions and pivot as necessary. In system development as well, companies must consider agile development in addition to conventional waterfall methodology.

This paper introduces a case study in which we applied agile principles to our business transformation initiative and to the development of its supporting systems in the business process re-engineering of production management within Kobe Steel's materials business. Section 1 describes the basic principles for applying agile methodology to the business process re-engineering of production management. Section 2 presents a specific use case.

1. Approach to applying agile methodology to the business process re-engineering of production management

1.1 Challenges in production management operations at Kobe Steel

Kobe Steel's materials business is known for responding flexibly to customer requests in providing a broad spectrum of high-quality products. Although many of our businesses operate on a smaller scale than that of our competitors, our accumulated expertise in production management enables us to efficiently produce a wide variety of products with minimal equipment by skillfully combining production resources, including those of our partners.

However, recent years have seen an increase in customer demand for improvements not only in product quality, on-time delivery, and supply chain security, but also in value creation based on new metrics such as low-CO₂ operation. As such, the degree of complexity in manufacturing, particularly in terms of production management, grows by the day. Furthermore, changes to the business environment, particularly following major capital expenditure or an expansion of production capacity, necessitate a restructuring of business processes in a way that capitalizes on the production management expertise cultivated. Responding to these challenges without delay requires the transformation of production management operations using digital data - in other words, the DX of production management.

1.2 Using agile methods in business transformation

Agile development is characterized by a team sharing a main goal, defining an incremental development process, and repeating iterations of small development cycles over a short period.⁴⁾ In traditional waterfall development, the entire project is divided into phases such as defining requirements, planning, and implementation. Standards are defined for each phase, and the project is advanced in a stepwise manner. Conversely, in agile development, PDCA cycles are repeated over a period from a few weeks to a few months to cover the project from determining the functions to be developed (e.g., by defining requirements) to implementation and testing.

Fig. 1 shows the process for re-engineering production management based on this information.

- (1) Define the new production management business process policy
 - Define goals and policies for the production management business process for the business model
 - Draft a workflow
- (2) Develop a new production management business process workflow
 - Develop a workflow based on agile principles and supporting tools
- (2-1) Make the operating procedure
 - Make the operating procedure and identify work areas to be systematized
- (2-2) Develop business support tools
 - Develop and improve business support tools in the work areas to be systematized
- (2-3) Trial operation
 - Trial operation using business support tools based on the workflow
- (2-4) Operating procedure reviews
 - Identify challenges, modify workflow/procedures, develop a plan for improving business support tools

Step (1) involves defining policies and workflows for the entire business. Step (2) is a cyclical process

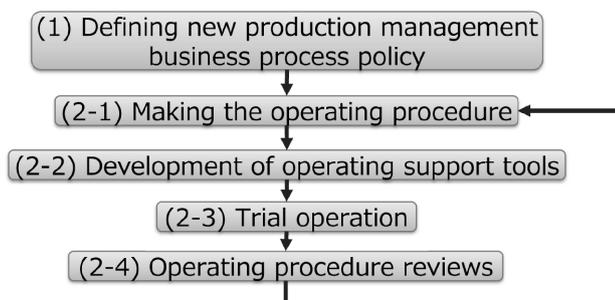


Fig. 1 Construction process of new production management

with the objectives of developing specific operating procedures, identifying and systematizing core tasks with a high burden, conducting trial operations, and identifying challenges and formulating improvement plans. This process entails multiple benefits: new operations are introduced at an early stage, production management personnel have time to comprehend and develop proficiency in the new operations, challenges associated with operations and tools are revealed early, and the entire business transformation is implemented in a stepwise manner.

2. Business process re-engineering of production management at our titanium plant

2.1 Overview of the production management business process at our titanium plant

Kobe Steel is the only integrated manufacturer in Japan that processes titanium from melting to the finished product. Kobe Steel's Takasago Works titanium plant manufactures rolled ring forged products of various shapes and materials, from pure titanium to titanium alloys, for domestic and international fuselage and engine manufacturers.

Numerous manufacturing processes are involved in producing titanium products from the raw material to the finished product. First, ingots are manufactured from titanium sponge, which is the raw material. The ingots are then forged into billets, which serve as the starting material for the end product. Billets undergo rolled ring forging, heat treatment, and machining on their way to becoming end products.⁵⁾

Because of the nature of this manufacturing process, rather than dedicated production lines for each product, Kobe Steel uses shared equipment for mixed-flow production to achieve efficient lot-size-one production of a range of products. The production management department has many practices that support this methodology. Beyond cultivating expertise in production management, it supports interdepartmental sharing of information, such as by devising production plans based on customers' manufacturing parameters and the available bandwidth of each manufacturing process and partner company. The department also manages the production plan's progress and revisions.

However, the landscape must change in response to the recovery in demand for aircraft components and similar products following COVID-19. Operations must expand to accommodate the large increase in volumes, meaning the production management business processes must be

transformed. In contrast to the previous approach of flexible production on a relatively small scale, operations must center around efficient and stable mass production. As such, we launched an initiative in 2021 to transform our operations based on data.

2.2 Plan for business process re-engineering of production management

Increasing throughput in a mixed-flow production process generally increases not only the workload, but also the inventory of intermediate products serving as a buffer between processes, extending manufacturing lead time; these phenomena occurred at the titanium plant.

Therefore, we established the guidelines below before introducing the new production management business process.

- Information related to production management should be shared among operations/departments, including sales, production management, and manufacturing.
- Manufacturing load and capacity per process must be more accurate.
- Bottleneck processes and the associated production planning must be optimized.

In addition to designing a workflow and data model based on the guidelines above, we also established policies for three major areas: master scheduling, operation scheduling, and surplus material management. **Fig. 2** shows a schematic diagram of the workflow and data model.

[Master scheduling]

- All processes required for long-term manufacturing load and capacity management can be computed centrally based on the sales plan prepared by the sales department for budgeting. Management aspects are divided up by process, product, and month, as appropriate. This provides a representation of the manufacturing load and enables the manufacturing department to

visualize material resource fluctuations. This prevents surplus intermediate product inventory and extended manufacturing lead time caused by operating above capacity.

[Operation scheduling]

- Production planning is based on sales-related data such as orders and inquiries to support make-to-order manufacturing, which entails producing only what is needed, when it is needed. This prevents the production of surplus intermediate product inventory.
- Scheduling is based on the theory of constraints (TOC)⁶. Specifically, the plan is initially devised so as to maximize the manufacturing capacity of the bottleneck process. The processes upstream and downstream of the bottleneck process are then planned, working outward from the bottleneck process. This prevents extended manufacturing lead time caused by operating above the capacity of the bottleneck process and the production of surplus intermediate products.
- Scheduling accounts for all necessary processes to manage the overall progress of the entire process. The plan is presented to the manufacturing departments responsible for important processes regularly, even if the manufacturing load is low. In addition, management records and presentation materials are updated to visualize fluctuations in the manufacturing load. This makes it possible to grasp the required manufacturing capacity by time period. This prevents surplus intermediate product inventory and extended manufacturing lead time caused by operating above capacity.

[Surplus material management]

- The plant's production capacity and conditions are also shared with the sales department. Part of the production planning workflow when considering inquiries includes evaluating whether minimum lot sizes are met and whether volumes can be adjusted to prevent

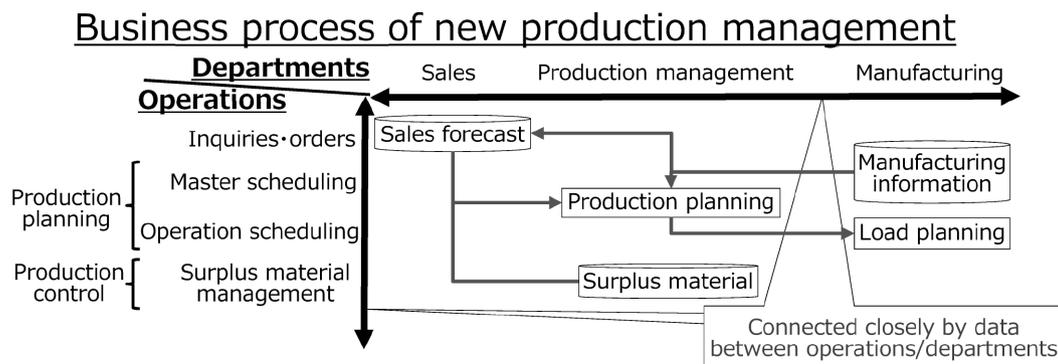


Fig. 2 Proposed production management business process

the production of surplus intermediate product inventory. The production management plan also prioritizes the use of intermediate products for orders and inquiries so as to minimize surplus intermediate product inventory. This prevents the production of surplus intermediate product inventory.

Specific business processes were designed based on the guidelines above. Fig. 3 illustrates the process for operation scheduling, which is described next.

- (1) Calculate the production quantity based on the sales information. Next, allocate intermediate products based on surplus material data, calculate the quantity of each product that must undergo new production, and confirm the customer delivery date for the order or inquiry. This minimizes production to only the volume necessary and prevents the production of surplus intermediate product inventory.
- (2) Draft a plan for each product's bottleneck process. First, the standard process delivery date of the bottleneck process is calculated based on the standard manufacturing lead time between the bottleneck process and the customer delivery date. A load-balancing plan is then developed based on the standard process delivery date and the manufacturing capacity information provided by the manufacturing department. This prevents the bottleneck process from extending the lead time because of a delay in the start of manufacturing.
- (3) Calculate the production quantity of the manufacturing processes upstream and downstream of the bottleneck process, as well as the standard process delivery date based on the schedule of the bottleneck process. The standard process delivery dates of the upstream and downstream processes are then calculated by backward/forward progression, starting from the standard process delivery date of the bottleneck process and using the standard manufacturing

lead time between each process. This makes it possible to load balance among the upstream and downstream manufacturing processes based on the bottleneck process.

- (4) Hold regular meetings with the manufacturing department to coordinate the plan for each process and the manufacturing load calculated based on the plan. If the manufacturing load exceeds the manufacturing capacity for a given process, determine appropriate measures to balance the load or increase capacity. This secures the necessary manufacturing capacity and prevents an extended manufacturing lead time caused by a delay in the start of manufacturing within any process.

2.3 Applying agile methodology to new operations and improvements

It would be impossible to perform each of the new business processes described in the previous section manually. However, designing and developing a single management system would take extensive time and introduce a high risk of the system not meeting the varying requirements inherent to each manufacturing operation.

In this initiative, we selected core operations with high workloads and developed simple business support tools using agile methodology to support business operations while establishing and improving the new business processes.

Specifically, we developed support tools to devise plans for bottleneck processes (item (2)), calculate process-specific delivery dates based on the bottleneck process plans and progress management (item (3)), and manage the manufacturing load and capacity for each process (item (4)). We also organized the data necessary for production management (shipping plans based on sales information, intermediate product inventories, manufacturing results by process, etc.)

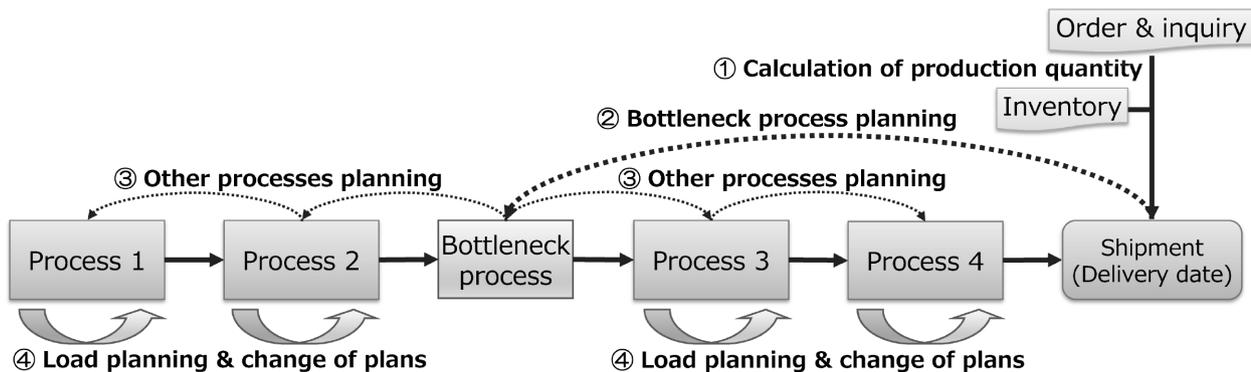


Fig. 3 Proposed operation scheduling process

and shared them throughout the plant alongside the manufacturing load and planning information calculated by the tool.

Members of the project developed each tool in house inside of about 2-3 months. After go-live, production management leadership communicated issues revealed through operation. We conducted PDCA cycles to release an improved version once per month.

Item (2), bottleneck process planning, is described next by way of example. Specific aspects covered include the application to new operations and the kaizen process for operation scheduling of the rolled ring forging process.

Most orders placed with Kobe Steel for rolled ring forging parts are manufactured by mixed-flow production. However, improving throughput necessitates lot production, in which the same product is rolled continuously.

The associated production plan must incorporate a massive amount of data (several thousand to tens of thousands of items) to cover the medium to long term; performing this task manually would be impractical. Therefore, we decided to use a support tool to automatically formulate a monthly production plan once the sales department provides sales information. Detailed below were our basic requirements for the tool's functionalities.

- i Sales and intermediate product information feed the calculations for the quantities of each product that must be produced and the delivery dates for orders and inquiries, which can then be confirmed.

- ii The standard process delivery time for the rolled ring forging process is calculated by subtracting the standard manufacturing lead time for the rolled ring forging process from the customer delivery date.
- iii Standard process delivery dates are prioritized, and orders and inquiries are sequenced accordingly. The standard lot size is set with productivity being the main factor, orders and inquiries are consolidated into lots, and the sequence of lot production is determined.
- iv The manufacturing date and time for each lot are calculated based on manufacturing capacity information (takt time) linked from the manufacturing department.

Table 1 shows a sample automated operation scheduling plan. Multiple orders and inquiries are consolidated into lots. The manufacturing date and standard process delivery date are indicated for each lot to reveal the margin to the manufacturing date in days. The production planning manager evaluates the risk of late delivery based on the margin and can take the following actions if necessary:

- Develop a plan to make up for lost time in downstream processes
- Extend equipment operating hours (overtime support)

The production planning manager can also investigate other measures to mitigate the risk of delayed delivery.

We designed and deployed the initial version of the tool to operations at an early stage. We then initiated the kaizen cycle shown as steps (2-1)

Table 1 An example result of operation scheduling planning

Order				Bottleneck process					
No	Types	Delivery date	Qty	①Standard delivery date on the process	②Start date	End date	Margin (①-②)	Lot ID	Takt time
1	A	2023/08/31	7	2023/07/12			2		
2	A	2023/09/14	2	2023/07/26	2023/07/10	2023/07/19	16	L1	57
3	A	2023/09/30	3	2023/08/11			32		
4	B	2023/09/06	5	2023/07/18			-1		
5	B	2023/09/14	5	2023/07/26			7		
6	B	2023/09/21	5	2023/08/02			14		
7	B	2023/09/28	5	2023/08/09	2023/07/19	2023/07/24	21	L2	37
8	B	2023/09/30	5	2023/08/11			23		
9	B	2023/10/07	5	2023/08/18			30		
10	B	2023/10/14	2	2023/08/25			37		
11	C	2023/09/12	4	2023/07/24	2023/07/24	2023/07/24	0	L3	5
12	D	2023/09/15	5	2023/07/27	2023/07/24	2023/07/25	3	L4	5
13	E	2023/09/20	10	2023/08/01			7		
14	E	2023/12/20	10	2023/10/31	2023/07/25	2023/08/02	98	L5	47
15	E	2024/02/20	5	2024/01/01			160		
3	A	2023/09/30	12	2023/08/11	2023/08/02	2023/08/11	9	L6	57
10	B	2023/10/14	3	2023/08/25			14		
17	B	2023/11/14	10	2023/09/25	2023/08/11	2023/09/17	45	L7	37
18	B	2023/11/21	9	2023/10/02			52		

through (2-4) in Fig. 1 to improve operations and the tool in tandem. Around 25 issues surfaced during this period. We prioritized improvement plans and released new versions in conjunction with monthly planning activities.

These efforts made it possible to quickly formulate monthly production plans that maximize the throughput of bottleneck processes (the original objective). They also spurred kaizen-related communication and activities initiated by personnel throughout the organization.

We successfully transformed the entire production management business process - a feat that would normally span several years - in one year: three months for planning, three months to develop the tools, and six months for agile-guided improvement. As a result of this initiative, we reduced the manufacturing lead time for rolled ring forged products, a core product line, by two-thirds and cut the related inventories by half. We also reduced warehousing costs and unexpected shipping costs by mitigating delays in production, resulting in concrete economic benefits beyond expectations.

Conclusions

This paper describes the usefulness of agile principles in the promotion of DX, explains the process of using agile methodology in the business process re-engineering of production management,

and describes the implementation and effects of these initiatives by means of the case study of Kobe Steel's titanium plant.

We have thus confirmed the applicability of agile principles for the business transformation of legacy production management operations, which have numerous constraints and rely on accumulated know-how.

Production management connects customers to manufacturing and ensures that customers receive the full potential value of products. We will use this initiative as a starting point to promote DX initiatives and thereby deliver even greater value to our customers.

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